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SEED TREATMENTS FOR FIELD AND VEGETABLE CROPS[1]

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Seed treatment is among the simplest and least expensive methods of controlling certain types of plant disease. It is effective against many seed-borne diseases and against many soil-borne organisms that cause seed decay or infection of young seedlings. Its use is limited, however, by the tolerance of different seeds to specific fungicides and by the toxicity of different fungicides to specific parasitic organisms. It is not a protection against rust, downy or powdery mildews, or virus diseases.

Before making seed-treatment recommendations, one must study the cycle of development of the disease, test the toxicity of available chemicals, and determine the tolerance of the seeds to effective materials under different environmental conditions. From trials conducted in experiment stations throughout the United States, information has been compiled regarding the most effective seed treatments for use on different vegetable and field crops. In several cases two or more materials appear almost equally effective on a certain crop; but as far as possible they are listed here in order of preference. Since new materials and methods are being developed and tested, some of the recommendations will probably be changed in the future.

The chemicals mentioned in this circular are all commercial products and will usually be found in the larger seed or fungicide and insecticide stores. For information concerning local sources consult the county farm advisor's office. Unless otherwise specified, the fungicides are to be applied to the seed as a dust.

Directions for use of the materials are furnished by the manufacturers with the containers.

SEED-TREATING EQUIPMENT AND METHODS

Small packets of vegetable seeds can be treated by adding a little dust on the point of a knife. After the packet has been shaken until the seed is thoroughly coated, all excess dust should be removed.

Fig. 1--Diagonal barrel seed-treater mounting for pickup trucks.
(Plans and photographs by O. C. French, Division of Agricultural Engineering.)

Small bulk lots of vegetable seeds can be treated in a glass fruit jar, a paper bag, or some similar container that can be shaken by hand.

Large lots of vegetable or field-crop seeds can be treated effectively in a diagonal barrel seed treater. Figure 1 shows a convenient method of mounting this type of treater on the back of a pickup truck.[4]

[1] The information contained in this circular was secured from several sources. In part it was obtained from original research conducted by several members of the Division of Plant Pathology. Other parts are based on investigations and recommendations of other experiment stations. The writers have also utilized the results of cooperative seed-treatment tests conducted by the Committee for Coordination in Cereal and Vegetable Seed Treatment Research of the American Phytopathological Society.

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[4] Detailed plans for this treater and the mounting can be secured from the Division of Agricultural Engineering, College of Agriculture, Davis.

A weighed or measured lot of seed should be placed in the barrel treater (not over half full), and a measured amount of the dust scattered over the seed. The barrel should next be turned slowly from 50 to 100 turns, and the seed may then be emptied into a sack or other container. A sacking device (illustrated in figure 1) will prove helpful.

For large-scale operations a number of commercial, continuous-flow seed treaters have been developed. These are entirely satisfactory provided the dust and seed feeds are balanced to apply the correct dosage in a uniform manner and provided the seed and dust are mixed enough to cover the seed uniformly before delivery at the outlet.

COMPATIBILITY OF SEED TREATMENT AND BACTERIAL INOCULATION

In some areas it is considered advisable to inoculate seeds of peas or other legumes with bacterial cultures because of the absence or paucity of nodule-forming organisms in the soil. Treating seeds with copper, mercury, or zinc fungicides either before or after inoculation will almost totally destroy the bacterial organisms on the seed. Spergon is only mildly toxic to the bacteria and may be used in combination with inoculation, provided the dosage of Spergon is low (1½ to 2 ounces per 100 pounds of seed) and provided the amount of inoculum is increased. The seed, after treatment with Spergon, should be inoculated with the bacterial cultures and then planted as soon as possible.

PRECAUTIONS

Several of the dust fungicides mentioned in this circular are poisonous, and the others are at least irritating to most operators. Treating equipment should be so arranged that there will be as little free dust as possible. It should be located outdoors or near a large opening, and the air movement should carry the dust away from the operators. In addition, a dust-excluding mask should usually be worn.

Treated seed should bear a distinctive marker indicating the material and dosage used and the date of treatment.

Seed treated with any of these fungicides should never be used for food and should not be fed to domestic animals.

CEREAL CROPS

The primary purpose of seed treatment of cereal crops is to control seed-borne diseases such as the well-known bunt or stinking smut of wheat. Occasionally such treatment has the further advantage of improving stands by protecting young seedlings against soil organisms. Often the grower cannot be sure of the degree of disease contamination in the seed he uses. For most of the grains, including wheat, barley, oats, and grain sorghum, seed treatment provides a form of insurance against losses from certain diseases.

The various smuts are perpetuated from year to year in one of several ways. The spores may be released at threshing time and deposited on the surface of the seed; or wind-borne to the open flowers of the normal plants; or deposited in the soil and, as in common corn smut, kept there in a viable condition for several years.

Barley: Covered Smut.--The spores are disseminated at harvest time and are lodged on and to some extent under the glumes.

Control: New Improved Ceresan at 1 ounce per 100 pounds of seed. (This same treatment will control two other important diseases of barley--black loose smut, and stripe.)

Barley: Black Loose Smut.--This disease is similar to covered smut in its cycle of development except that the spores are disseminated at blossom time and may germinate, the resultant mycelium penetrating the tissues of the glume and seed coat.

Control: New Improved Ceresan at 1 ounce per 100 pounds of seed.

Barley: Brown Loose Smut.--This disease is similar, in its cycle of development, to the loose smut of wheat. Unlike black loose smut (with which it is often confused) it is of no importance in California. No control, therefore, is necessary.

Barley: Stripe.--Although this is not a smut disease, the causal organism functions much as do the smuts. The spores, produced on the leaves of diseased plants, are wind-borne to the open flowers of normal plants and are thus carried over to subsequent crops.

Control: New Improved Ceresan at 1 ounce per 100 pounds; or copper carbonate, thoroughly and consistently applied at 3 ounces per 100 pounds of seed.

Corn: Seedling Diseases.--Certain seed- and soil-borne diseases can be adequately controlled by Semesan, Jr., used at the rate of 3½ ounces per 100 pounds of seed.

Corn: Smut.--Seed treatment may prevent the introduction of corn smut on the seed. It will not, however, control this disease after it has become established in the field, because the infection does not occur during germination of the seed, but appears on the aerial portions of the plant during the growing season. Sanitation, involving the removal and destruction of smutted plants or plant parts, and crop rotation are recommended.

Grain Sorghums: Kernel Smut.--The spores are produced on diseased plants in masses replacing normal kernels and are disseminated at harvest, being deposited on the surface of the normal seed.

Control: Copper carbonate at 4 ounces; or copper oxide (Cuprocide), used in the red form at 3 ounces or in the yellow form at 2 ounces; or New Improved Ceresan at 1 ounce per 100 pounds of seed.

Grain Sorghums: Head Smut.--The spores of this smut live over in the soil. This disease occurs to a limited extent in California, but seed treatment is not effective.

Oats: Covered and Loose Smut.--Spores of covered smut lodge on the seed at harvest time, whereas those of loose smut are wind-borne to the blossoms. In both diseases, however, mycelium or spores of the causal agent are superficial to the seed; a dust treatment is therefore effective.

Control: New Improved Ceresan at 1½ ounces per 100 pounds of seed.

Wheat: Bunt or Stinking Smut.--The spores of the fungus causing this disease are deposited on the surface of the seed. When this seed is planted, the spores germinate; and the mycelium (the vegetative growth of the smut fungus) penetrates the tissues of the seedling. The fungus thus grows within the tissues of the wheat plant. As the plant matures, invasion of the floral parts results in the production of the smut balls, which are masses of spores, in place of the normal kernels.

Several wheat varieties now available to California growers are resistant to bunt. The two most widely distributed are Baart 38 and White Federation 38, which are resistant to both bunt and stem rust. Pacific Bluestem 37 and Sonora 37 are resistant to bunt, but not to stem rust. It is recommended that at intervals of two or three years treatment be given even to seed of the resistant types.

Control: Copper carbonate at 3 ounces per 100 pounds of seed, or New Improved Ceresan at 3/4 ounce per 100 pounds of seed, The latter has occasionally produced injury to wheat seed in California under certain storage conditions.

Wheat: Loose Smut.--The spores of this fungus, produced on the heads of diseased plants, infect the flowers of normal plants at blossom time; and the mycelium becomes established in the embryo of the seed. In California this disease is occasionally found associated with seed produced in areas of high summer humidity or with seed introduced from certain areas of the United States. Because of the internal nature of the fungus, dusts are not effective; control can be obtained only by a hot-water treatment. This disease is so rare in California, however, that treatment is unnecessary.

OTHER FIELD CROPS

In contrast with cereals, the primary purpose in treating the seed of other field crops and most of the vegetables is to protect the germinating seeds and young seedlings against infection by soil-inhabiting organisms. Certain seed-borne diseases of these crops can also, however, be controlled by seed treatments.

Alfalfa: Damping-off.--Destruction of seedling stands in the past has been confined to relatively small areas. In the few tests conducted, an effective control has usually been obtained by treating the seed with New Improved Ceresan at 8 ounces per 100 pounds of seed.

Beans (Common Types).--Investigations on seed treatment of the common types of beans have been rather limited. Usually varieties such as Pink, Pinto, and Red Kidney produce satisfactory stands without treatment. Small whites and some garden varieties suffer from seed decay when planted in cold, wet soil. Spergon at 3 ounces per 100 pounds (0.2 per cent of the seed weight) provides considerable protection without injurious effects. Other seed treatments such as Semesan and Arasan are more effective under some conditions, but have not been tested enough in California to justify a definite recommendation.

Beans (Lima).--Both large and small lima beans are very susceptible to seed decay and pre-emergence damping-off, particularly in cold, wet soil. Under some conditions, however, they are severely injured by seed treatment with copper and mercury compounds--for example, red or yellow copper oxide, Ceresan, or Semesan. In numerous greenhouse and field experiments, both large and small lima beans have been safely treated with Spergon or Arasan, and these materials have given excellent protection against seed decay. Spergon at 4 ounces per 100 pounds of seed was used on more than 13,000 acres of large lima beans in Ventura County during 1943, with results so satisfactory that a much greater acreage will probably be treated in 1944. Arasan is also highly beneficial; but apparently a somewhat higher dosage, perhaps 0.4 per cent of the seed weight, may be necessary to provide as good protection as 0.2 or 0.25 per cent of Spergon.

Small lima beans can be protected by the same materials; but--to judge from field trials and observations--plantings in the interior valleys during warm weather do not ordinarily require seed treatment.

Blackeyes.--This crop is very susceptible to seed decay or pre-emergence damping-off, and in several areas the stands can be strikingly improved by seed treatment. For several years the standard treatment has been Semesan at 0.2 per cent of the seed weight (about 3 ounces per 100 pounds). In recent experiments, either Spergon or Arasan at the same rate gave considerable protection; but in both greenhouse and field trials the best results were secured with Semesan. Plantings made during high temperatures may not require seed treatment. In areas where seed decay is common, however, treatment with one of the three fungicides mentioned above is usually desirable.

Cotton.--Seed decay and seedling infection are often severe in early plantings, but are less apt to occur later in the season. They may be effectively controlled by treating linted seed with Ceresan at 9 ounces or New Improved Ceresan at 4½ ounces per 100 pounds of seed. Delinted seed requires only 5 ounces of Ceresan or 2½ ounces of

New Improved Ceresan per 100 pounds. Spergon, suggested for treatment of cotton seed in some of the southern states, has not been adequately tested in California.

Flax: Damping-off.--The destruction of flax seedlings by damping-off organisms has not been a factor in the San Joaquin Valley area. Damping-off caused by Rhizoctonia does occasionally produce losses in the Imperial Valley. In preliminary trials at Davis, a dosage of 2 ounces of New Improved Ceresan per 100 pounds of seed appeared effective.

Flax: Anthracnose.--This disease is both seed- and soil-borne. The best seed treatment now known will not completely eliminate the disease, but should be practiced if the seed will be planted in soil that has not been cropped to flax for a period of three years. New Improved Ceresan is used at 2 ounces per 100 pounds of seed.

The dosage recommended above should also be applied to seed imported from flax-producing regions outside California.

Peanuts.--Seed treatment of shelled peanuts with red copper oxide at a dosage of 0.5 per cent (8 ounces per 100 pounds) or yellow copper oxide at 0.3 per cent of the seed weight has proved highly beneficial in several areas of the San Joaquin Valley. In experimental trials Semesan and Ceresan at 0.2 per cent also gave good protection, especially in soils infested by Rhizoctonia. In certain southern states Arasan and Spergon are recommended for peanuts, but in limited trials in California they have not appeared satisfactory.

Peanuts in hulls, soaked in water for 12 to 24 hours to hasten germination, can be protected against soil organisms by dipping them for a few minutes in one of the following: (1) yellow copper oxide at 1 pound to 8 gallons of water, (2) Semesan at 1 pound to 24 gallons of water, or (3) Semesan Bel at 1 pound to 7½ gallons of water.

Sugar Beets.--To control damping-off caused by soil-borne Pythium or Rhizoctonia and seed-borne Phoma, the most satisfactory seed treatment for either whole or sheared seed is Ceresan at 1 pound per 100 pounds of seed or New Improved Ceresan at 6 ounces per 100 pounds of seed. (See fig. 2.) In areas where Pythium is the chief cause of damping-off, red copper oxide at 2 pounds or yellow copper oxide at 1½ pounds per 100 pounds of seed is effective. If, however, Rhizoctonia is abundant in the soil or the seed is infected by Phoma, the organic mercury compounds give better control. In limited trials Arasan appears to be a satisfactory seed treatment for sugar beets in light or moderately infested soils and deserves additional testing.

The beet-water-mold seedling disease that occurs most frequently in the peat or semipeat soils of central California is not controlled by any seed treatment. Early planting and rotation with nonirrigated crops are suggested.

Precaution: Beet seed treated with Ceresan or New Improved Ceresan should be planted soon after treatment because storage, especially under moist conditions, may result in injury after a few weeks.

VEGETABLE CROPS

Beets.--Seed for commercial plantings of garden beets may be treated with the same fungicides used on sugar beets in that area. For home plantings red or yellow copper oxide at 1 to 1½ pounds or Arasan at 0.5 pound per 100 pounds of seed is preferred because their use minimizes the possibility of injury in storage, eliminates highly poisonous dusts, and reduces the necessity for accurate dosage.

Beans.--Some garden varieties of beans are benefited by seed treatment with, for example, Spergon or Arasan, especially when they are planted in wet soils or under low temperatures. Under favorable conditions, treatment may not be needed; but further experience may prove it to be a desirable practice in many localities.

Beans (Lima).--Both large and small types should usually be treated with Spergon or Arasan; neither copper nor mercury dusts should be used on lima beans.

Blackeyes.--Blackeyes may be treated with Semesan, as is most of the commercial crop; but Spergon or Arasan is preferable for home use. See the discussion of bean-seed treatments under "Other Field Crops."

Cabbage Family (Crucifers).--This family includes cabbage, cauliflower, broccoli, Brussels sprouts, Chinese cabbage, radish, turnips, and the like. Quick-germinating types such as radish, turnip, and Chinese cabbage rarely need seed treatment to protect them from damping-off. Cabbage and cauliflower, however, may benefit from

Fig. 2.--Control of damping-off of sugar beets by seed treatment. The sixteen rows to the right of the center were planted with nontreated seed, while the rows to the left and the extreme right were planted with treated seed.

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protective fungicides in some areas. Semesan at 0.4 per cent (6 ounces per 100 pounds) is the most effective dust treatment; but zinc oxide at 2.0 per cent is used in some localities. Cabbage seed produced in the dry areas of the West is usually free of seed-borne pathogens, so that hot-water treatment is unnecessary.

Carrots.--In most areas satisfactory stands of carrots are secured without seed treatment. As a precaution against seedling infection, however, several large operators in the Salinas Valley treat carrot seed with Spergon at 6 ounces per 100 pounds of seed or Semesan at 4 ounces per 100 pounds. In the few tests conducted, there was little difference in the stand from treated and nontreated seed or between treatments.

Celery.--Because seedlings of this crop are apparently not very susceptible to damping-off, protective seed treatment seems unnecessary. Failure to secure stands more often results from drying of the surface soil during germination. Either the early-blight or the late-blight fungus may be carried on or in the seed parts. This fungus can be eliminated from the seed by chemical or heat treatments; but the use of seed more than two years old is an easier method of avoiding seed-borne infection. Seed less than two years old may be pre-soaked for 15 to 30 minutes in water; then treated for 15 minutes in a formaldehyde solution made by adding 1 tablespoonful of commercial formalin to 2 quarts of water; and finally dried and planted.

Lettuce.--Seed for commercial planting of lettuce in California is usually not treated with fungicides, and there is little evidence that such a practice would be advantageous. Test plantings in heavily infested soil show, however, that damping-off can be reduced considerably by seed treatment with red copper oxide, or with zinc oxide at 2 pounds per 100 pounds of seed. Spergon and Arasan have not been adequately tested on this crop.

Melon Family (Cucurbits).--This family includes watermelon, cantaloupe, squash, pumpkin, and the like. Seeds of most of these cucurbits are very susceptible to decay in cold, wet soil but usually escape infection when planted in a warm, moist place. Treatment with Semesan at 5 ounces per 100 pounds of seed, Spergon at 8 ounces, red copper oxide at 8 ounces, or yellow copper oxide at 5 ounces will usually provide good protection against soil fungi. Seed that has already been soaked in water to hasten germination may be dipped, just before planting, in a suspension of yellow copper oxide at 2 pounds per 10 gallons, or Semesan at 1/5 of a pound per 10 gallons, or Semesan Bel at 1 1/3 pounds per 10 gallons. One gallon of suspension should be used for each pound of seed to be treated. In soil heavily infested by Rhizoctonia the organic mercury compounds listed above give better control than copper oxide.

Onions.--No seed treatment is considered necessary for onion seed in California. Damping-off is apparently not an important factor, and onion smut is not known to occur in the state.

Peas.--Seed decay is so severe on the varieties of peas grown in California that treatment is almost universally practiced. Spergon at 3 ounces per 100 pounds of seed is most commonly used because it provides satisfactory protection under nearly all conditions. It has the further advantages of being easy to apply, having low toxicity to man and animals, requiring no lubricant for machine planting, and being safe for use on seeds that will be planted under different conditions or held in storage. Semesan at 4 ounces per 100 pounds is a very effective seed protectant, but lacks some of the advantages listed above. Red copper oxide at 4 ounces per 100 pounds provides good protection but, because it increases friction, requires a lubricant (graphite) for machine planting. Yellow copper oxide at 2½ ounces per 100 pounds gives excellent protection, but delays emergence of some varieties, especially when planted under cool conditions.

Potatoes.--Tubers infected with Rhizoctonia or scab should be treated, before cutting, in one of the following solutions:

Mercuric chloride (corrosive sublimate): Use at a 1-1000 dilution (4 ounces to 30 gallons of water). Soak for 1½ hours at 50° to 75°F. Dry the tubers: then store them whole, or cut and plant them.

Cold formaldehyde: Soak the tubers for 1½ hours in a solution made by dissolving 1 pint of commercial formalin in 30 gallons of water.

Semesan Bel: Mix 1 pound of the powder in 7½ gallons of water. Dip the tubers long enough to wet the surface thoroughly. Drain, cut, and plant them; or dry and store them.

For details of the hot or acid corrosive sublimate treatments or hot formaldehyde treatment, see Farmers' Bulletin 1862 (cited at the end of this paper).

These treatments will not protect the potato plants against Rhizoctonia or scab infection from the soil. Nor will they prevent virus diseases or bacterial ring rot, which are carried inside the tubers; against these the use of certified seed is the best assurance.

Spinach.--Since this crop is very susceptible to damping-off, the use of treated seed is highly desirable. Good protection can be secured by treating spinach seed with red copper oxide or zinc oxide at 2 pounds, or yellow copper oxide at 1½ pounds, per 100 pounds of seed. In recent tests, Arasan at ¼ to ½ pound per 100 pounds of seed compared favorably with the treatments mentioned above.

Sweet Corn.--Protection against both soil- and seed-borne organisms can be secured by treating sweet-corn seed with Semesan, Jr., at 3½ ounces per 100 pounds of seed. Disease-free seed will usually give a satisfactory stand without treatment except in heavily infested soil, or in soil excessively wet after planting. Arasan and Spergon also offer considerable protection against soil organisms and may be preferred for home-garden use.

Sweet Potatoes.--For the control of black rot, stem rot, and scurf, sweet potatoes for seed should be treated with mercuric chloride or Semesan Bel before bedding. Mercuric chloride (corrosive sublimate) is used at a 1-1000 strength (4 ounces to 30 gallons of water); the roots are soaked for 8 to 10 minutes and then bedded without washing. Semesan Bel is mixed with water at 1 pound to 7½ gallons; the roots are dipped long enough to wet the surface, then drained and bedded. Some experiment stations now recommend a 10-minute dip in 2½-per cent borax solution.

Swiss Chard.--The same seed treatment suggested for garden beets or sugar beets may be used for Swiss chard.

Tomatoes.--Tomato seeds are treated for two purposes: first, to eliminate surface-borne organisms such as those causing bacterial canker or Fusarium wilt; second, to protect the seed and young seedlings against damping-off. The first purpose can be accomplished by soaking the seed in a 1-2000 solution of mercuric chloride for exactly 5 minutes. The mercuric chloride at the rate of 1.9 grams of powder, or 4 large tablets or 16 small tablets per gallon of water, should be dissolved in a wooden or earthenware container. The seed is then placed in a loosely woven cloth bag not over half full and immersed in the solution (1 gallon for each pound of seed). The bag of seed should be agitated with a paddle while in the solution. At the end of 5 minutes remove the bag, and immediately wash it in running water for 15 minutes. Then dry the seed thoroughly. Use a fresh solution for each lot of seed.

After drying, the seed can be protected against damping-off by treatment with yellow copper oxide at 1½ per cent of the seed weight (1 level teaspoorful of dust for each pound of tomato seed).

The tomato-seed treatments described above have been used successfully in California for several years. Recently some eastern experiment stations have recommended a single treatment in New Improved Ceresan solution instead of the two treatments mentioned above. This eastern method was tested extensively in California during 1943 and was found both safe and effective when properly applied. The seed is soaked in a 1-1200 solution of New Improved Ceresan (1 ounce in 9 gallons of water) for exactly 5 minutes. It is then drained and dried without washing. One gallon of solution is used for each pound of seed. The procedure is effective against both seed- and soil-borne organisms. It may, however, be harmful to germination, especially if the seed is stored wet or in tight containers.

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